Quick Reference to Climate Considerations

Every USACE project is to some degree affected by changing climate and related conditions. The need to understand these impacts is even more critical as the USACE moves forward with planning, design, and construction of the regular program and the 2018 Emergency Supplemental projects appropriated under Public Law 115-123. We address here three relevant climate factors to achieve expedient climate risk-informed decision-making[1]: datums, sea level change, and climate-impacted hydrology. This quick reference synthesizes but does not supplant or replace existing policy and guidance.

1. Datums.

a. Do we have policy requirements for vertical datums? Yes, ER 1110-2-8160 lays out the policy for using a nationwide system of tidal and geodetic datums. This three-page ER applies to planning, engineering, design, construction, operation, maintenance, and regulation of flood risk management and coastal storm damage reduction, hurricane protection, multi-purpose water supply/control and hydropower, ecosystem restoration, navigation projects and regulatory permitting activities. While EM 1110-2-6056 explains how to comply with the policy and provides checklists, we suggest reaching out to subject matter experts (SMEs) in the Surveying & Mapping and Climate Preparedness and Resilience (CPR) Communities of Practice (CoP) for quick results.

b. Is this policy important in planning studies and engineering design? Yes, because the ***water level on the ground*** is one of the most important constraints in formulating a plan to meet the study objectives and is required for many loading factors, design decisions, and/or material and cost estimates. Datums are especially important for a coastal study or a study where water levels are tidally affected now and in the future (e.g., estuaries, wetlands, rivers), and where land subsidence is high or crustal uplift occurs. The ***datum is therefore a key risk factor*** to be considered in identifying both current and future vertical elevations.

c. Why do we have this policy? We have this policy because 1) USACE designs need to function in their intended purpose to the intended level for the life of the project. 2) Datum misinterpretation can lead to gross errors in assessing USACE project effectiveness or economic consequences. Learning from a mistake of the past has precipitated the need for a consistent vertical datum, especially, in areas affected by changing conditions. Addressing the deaths and economic consequences of Hurricane Katrina in 2005, the Interagency Performance Evaluation Task Force (IPET) study revealed variations of between 0.2 to 3 ft in structure elevation due to subsidence and errors in interpreting vertical datum information which affected “wave heights and water level elevations, high-resolution hydrodynamic conditions, water elevations of hydrostatic forces and loadings at levees and floodwalls, elevations of pump station inverts, and related elevations of flood inundation models deriving volumes or first-floor elevations in residential areas.” IPET also stated that ***datum misinterpretation*** “resulted, in the case of the outfall canals, in structures built approximately 1 to 2 feet below the intended elevation.” ER 1110-2-8160 was established to avoid these problems.

[1] *Risk-informed decision making* is a process by which risks are to be assessed, managed, and communicated throughout the USACE using estimates of risk that are combined with non-risk factors and insights to reach more complete, transparent, and informed decisions. All risk-informed decisions will be documented with appropriate discussion of assumptions, rationale, and uncertainties.

d. Will this critical risk factor delay a project with a tight schedule? No. There is a well-known, established method in place. Each district should have a certified district datum coordinator who can assist. If not, reach out to Surveying & Mapping and CPR CoP SMEs for quick results.

2. Sea Level Change.

a. Do we have policy requirements to incorporate changing sea levels? Yes, since 1986, sea level change has been a recognized risk factor for USACE coastal projects. The current policy is ER 1110-2-8162, which is guidance for incorporating the ***direct and indirect physical effects of projected future sea level change*** (SLC) across the project life cycle in managing, planning, engineering, designing, constructing, operating, and maintaining USACE projects and systems of projects. ETL 1100-2-1 explains how to comply with the policy. We suggest reaching out to CPR CoP SMEs for consultation on approaches and quick results.

b. Is this policy important in planning studies and engineering design? Yes. There is ***no question*** that local mean sea level has changed over the observed record and will continue to change into the 22nd century. Locally, these changes may result in a net increase or decrease of mean sea level relative to the land surface depending on local effects such as land subsidence or tectonic activity, regional effects including circulation, and observed global long-term sea level rise. Consideration of SLC is required for a coastal study or a study where water levels are tidally affected now or in the future (e.g., estuaries, wetlands, rivers). As SLC changes over time, it can cause shoreline erosion, altered operational reliability, and changing flood risks. ***SLC is therefore a key risk factor*** and is to be computed at the start of a study or design.

c. Why do we have this policy? The policy was instituted because sea level change is a reasonably foreseeable future condition that is dynamic and it is no longer sufficient to assume a static future condition that is the same as current conditions. Uncertainty in the future *rate of change* of mean sea levels is accounted for by using three scenarios of SLC: low, intermediate, and high rates. ETL 1100-2-1 further recommends that the scenarios are used to determine the range of times at which threshold or trigger elevations associated with project elements or components are likely to be equaled or exceeded. This can be termed the "*when, not if*" approach. ER 1100-2-8162 reminds us that although the period of economic analysis is typically 50 years, engineering designs should account for conditions over the entire project design life. ER 1110-2-8159 may require a longer planning horizon of 100 years for major infrastructure projects, for which SLC can be a significant factor in planning and design.

d. Will this critical risk factor delay a project? No. Since 2009, many districts have built technical expertise in addressing SLC and its direct and indirect impacts. While complex hydrodynamic models are available for use in complex, high-consequence projects, simple tools have been developed so that early planning phases or uncomplicated projects can obtain ***order of magnitude estimates of SLC in a matter of hours***. The Sea Level Curves Calculator, which has been in use since 2012, allows users to estimate SLC into the future for NOAA tide gauges with sufficient record length[2] using both the USACE scenarios and those published by others. Users can select datum, add NOAA-calculated extreme water levels by superposition, enter an index value for superposition, and add two critical elevation thresholds for comparison. The Sea Level Tracker provides information on observed mean sea level (MSL) and its indirect water level effects along with comparisons to the USACE SLC scenarios. We suggest reaching out to CPR CoP SMEs for consultation on approaches and quick results. Examples are shown in Figures 1 and 2.

[2] And for selected non-NOAA long term tide gauges, primarily those maintained by USACE in Louisiana

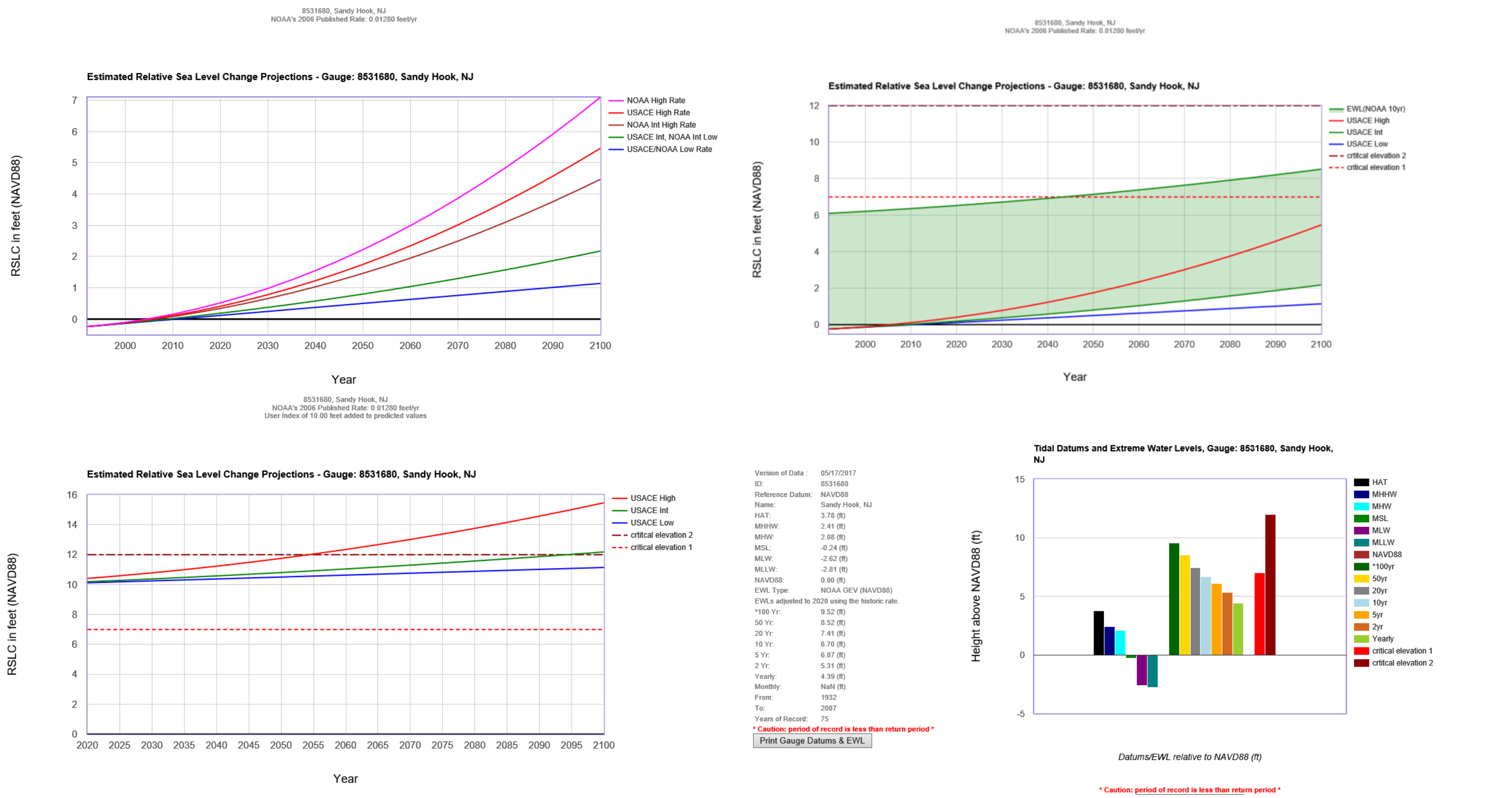

Figure 1. Estimated sea level change curves for NOAA Tide Gauge Sandy Hook, NJ for 1) Upper left, using the NOAA 2012 scenarios in addition to the USACE 2013 scenarios, with a datum of NAVD88 per ER 1110-2-8160 for a flood/coastal storm risk project and referenced to 1992, the midpoint of the latest National Tidal Datum Epoch; 2) Upper right, USACE curves with 10% annual exceedance probability (AEP) NOAA-calculated extreme water levels superposed on the intermediate scenario for comparison to two user-entered critical elevations of 7 and 12 ft NAVD88 – the lower of which will be exceeded by the 10% AEP event around 2040 and the higher robust to the 10% AEP for all three scenarios to 2100; 3) Lower left, the three scenarios superposed on a user-entered *index value* of 10 ft (which could represent, say, a calculated still water level of 1% AEP or the FEMA 0.2% AEP water level) with a project start date of 2020 (scenarios still begin at 1992) and the same critical elevations; and 4) Lower right, the stick diagram required by ER 1110-2-8160 picturing project datum relationships and NOAA-calculated extreme water levels.

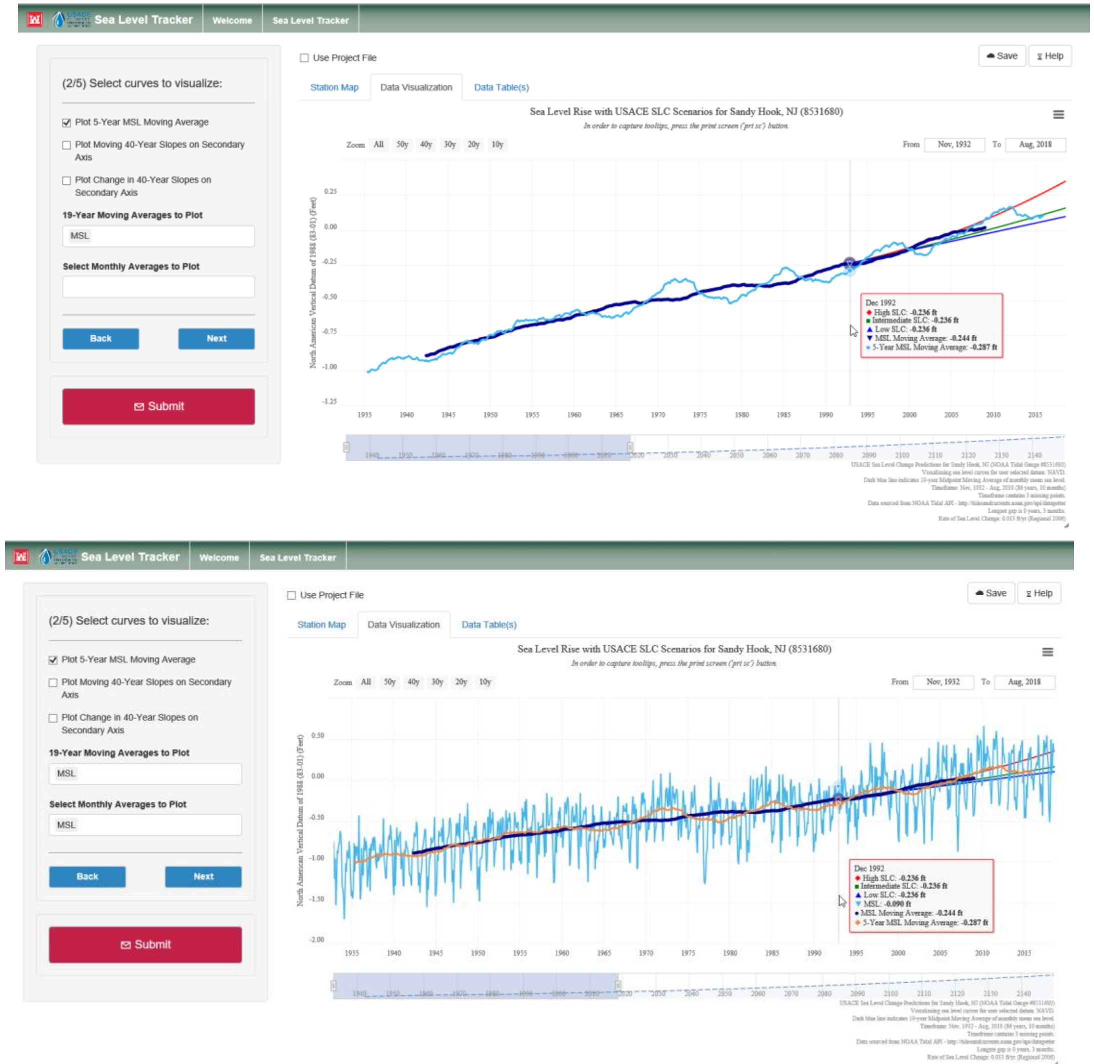

Figure 2. Sea Level Tracker results for the same tide gauge, showing 1) Top, the 19-yr midpoint moving average mean sea level (MSL) at the site providing long-term SLC, the 5-yr midpoint moving average MSL which depicts the interannual and multi-decadal variability at the site, and the three USACE scenarios beginning in 1992; 2) Bottom, the same with the monthly MSL added for the period of record, showing the seasonal variability. At this tide gauge, the observed monthly variability is much greater than the range between the three scenarios.

3. Climate-Impacted Hydrology.

a. Do we have policy requirements to incorporate climate impacts into hydrologic analyses? Yes, since 2014, climate change ***impacts to current and future hydrology have been recognized as a risk factor*** for USACE projects. Current guidance includes Engineering and Construction Bulletin (ECB) 2018-14, which provides guidance for assessing the impacts of climate change on project hydrology, including potential nonstationarities (ETL 1100-2-3). This ECB requires a qualitative assessment of potential long-term risks to project performance, but does provide for quantitative assessment of projected hydrologic changes to projects if necessary. Teams should reach out to CPR CoP SMEs for consultation and collaboration on any quantitative impact assessments. ECB 2018-14 aligns the climate change analysis (Figure 3) with SMART planning milestones, consistent with PB 2018-01.

b. Is this policy important in planning studies and engineering design? Yes. Observed and projected hydroclimatic changes can alter the frequency, magnitude, and timing of peak flows, and the duration and magnitude of low flows, with many places experiencing conditions outside those recorded in historical observations. Where these changes have already been observed (e.g., through analysis according to ETL 1100-2-3), or are anticipated to be more extreme in the future, relying solely on historical observations for project design is insufficient to guarantee the design-level of performance in the future. ECB 2018-14 provides initial guidance for addressing the impact of anticipated changes in extreme rainfall events, extreme droughts, and abrupt shifts between these two states on project performance. CPR CoP SMEs can help teams produce additional information, such as regional assessments of nonstationarity (Figure 4), time series analyses for variables of interest (Figure 5), or a quantitative estimate of the range of future flows based on an ensemble of projections (Figure 6).

c. Why do we have this policy? We have this policy to ensure that future without project conditions incorporate long-term changes in hydroclimatic conditions, and that these are accounted for during project design in a scientifically-valid, consistent way across all USACE projects. The impacts of climate change can be reduced or magnified by local and regional conditions, such as the degree of watershed urbanization or the season when precipitation intensity is at its greatest. Finally, different watershed problems and solutions are likely to be differentially impacted by climate change: a single national assessment of vulnerability would miss many project-specific impacts. Consequently, this policy addresses the need for climate change vulnerability to be assessed on a project-by-project basis.

d. Will this critical risk factor delay a project? No. Tools have been developed to facilitate the analysis of project vulnerabilities and are available on a single web portal. These tools include the Civil Works Vulnerability Assessment Tool, the Nonstationarity Detection Tool, and the Climate Hydrology Assessment Tool. Additional tools and datasets are under development to further reduce analysis time. The portal also provides a centralized point for accessing a variety of key information resources, such as the National Climate Assessment, USACE climate summaries by major watershed, example analyses conducted by districts, as well as reports by Reclamation and others. We encourage districts to reach out to CPR CoP SMEs for help conducting the analyses, using the tools, and identifying background information sources.

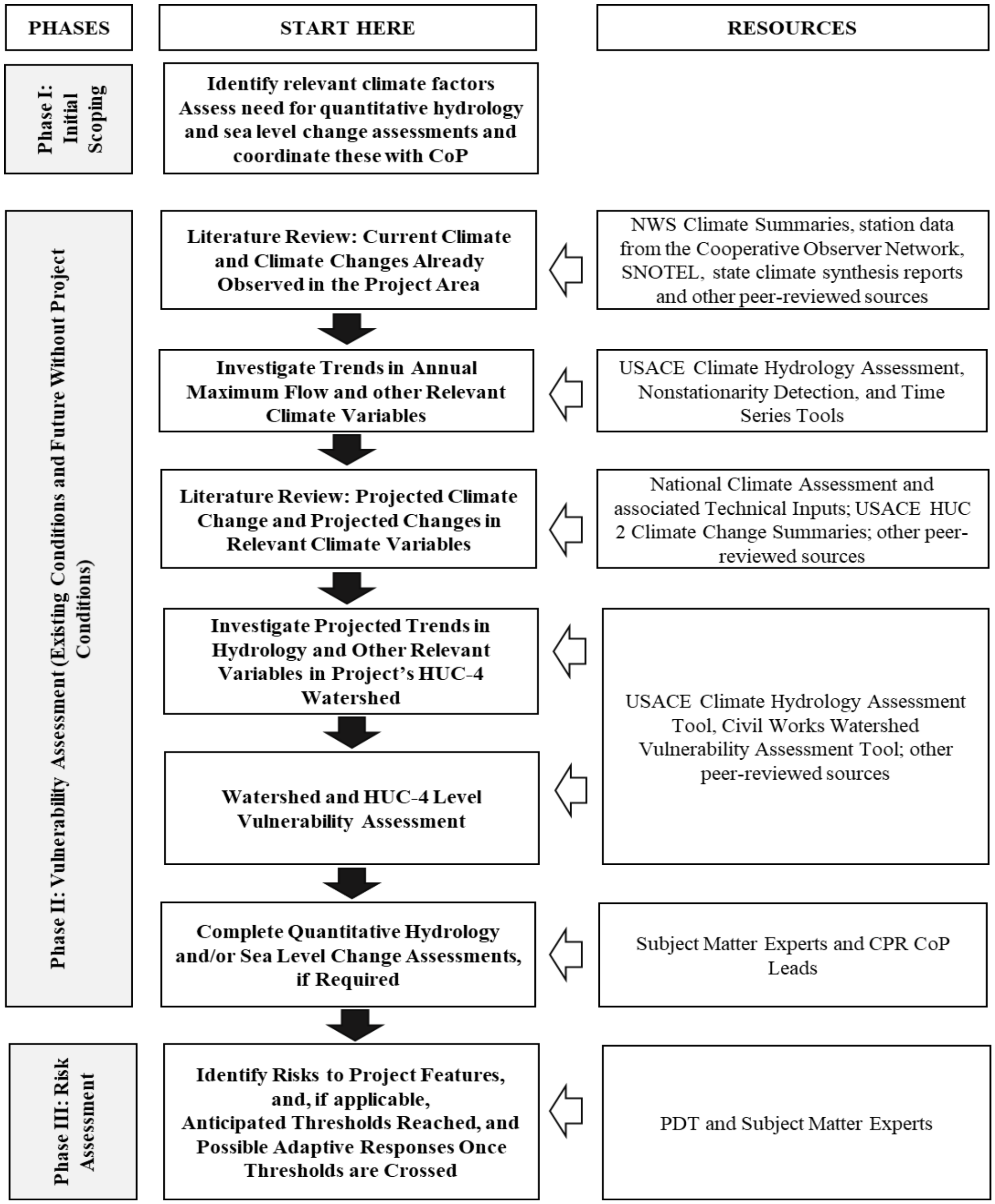

Figure 3. Steps to perform a qualitative assessment of the impacts of climate change in hydrologic analyses. Quantitative analyses are described in ECB 2018-14, Attachment C.

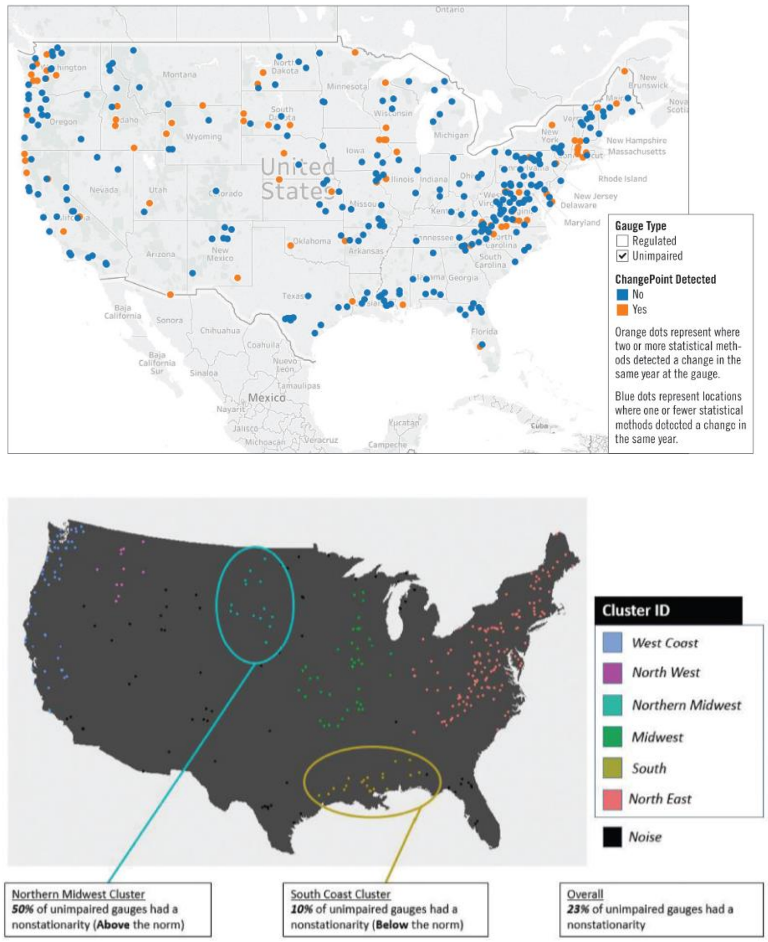

Figure 4. Nonstationarity detection for USGS unimpaired stream gauges (top), and regional clusters (bottom). Regional clustering can be performed sub-regionally using unregulated flow datasets rather than or in addition to USGS streamgages.

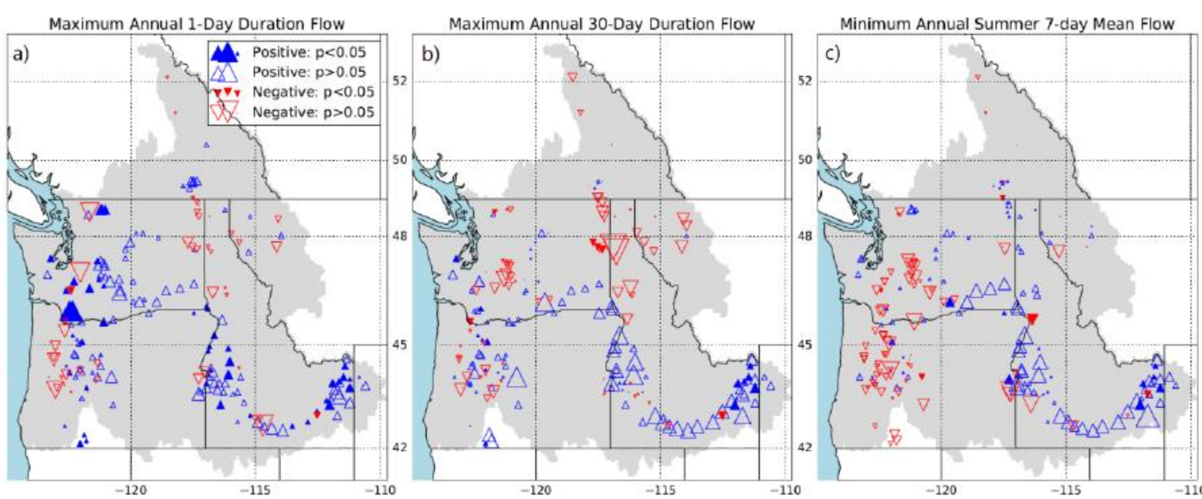

Figure 5. Example regional monotonic trend analysis conducted by district using some of the same methods in the time-series toolbox.

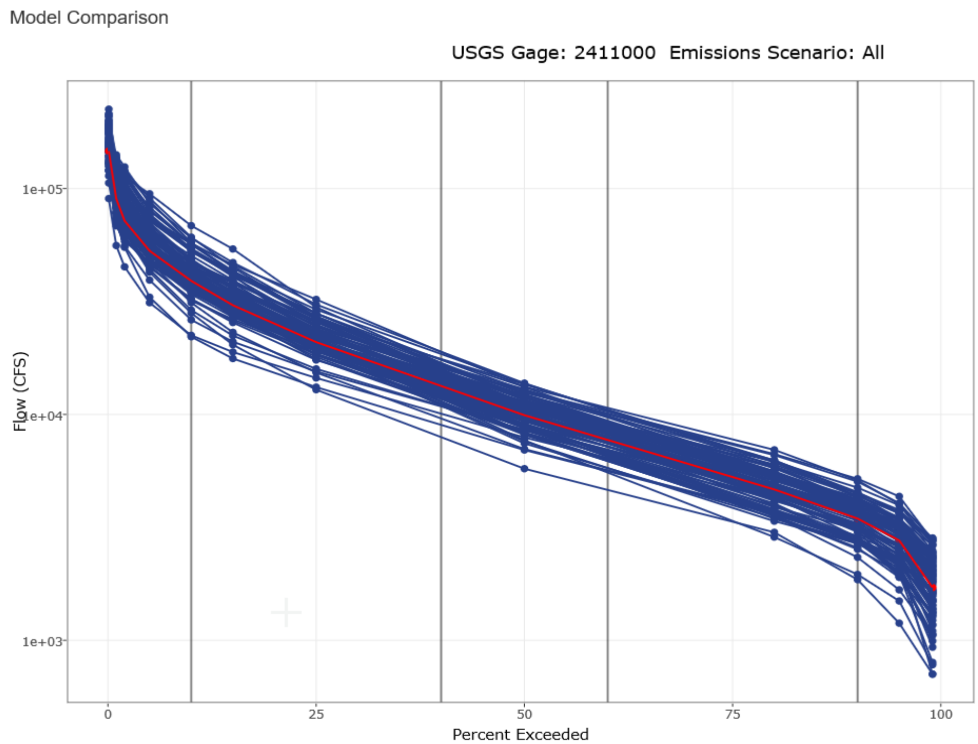

Figure 6. Example of quantitative analysis which compares the annual duration curve developed from observed data over the period 1950-1999 (red) with climate-impacted projected flows for the period 2053-2083 based on an ensemble of projections (blue).